II. POSITIONING BY NNSS; SATELLITE FIXES AND DEAD RECKONING

Masato Joshima and Koji Onodera

NNSS is the only efficient way for accurate positioning in this survey area. Loran or Omega is not so efficient in this area. Examples of positions obtained by Loran and Omega are shown in Fig. II–1 as well as the positions obtained by recalculated NNSS in the same area.

Although positioning by NNSS is more accurate than other methods, much errors are included in the dead reckoning system. The errors are mainly due to misestimation of water velocity. As satellite fixes give us accurate positions at each fix time, we can recalculate the water velocity between the satellite fixes and then obtain the recalculated positions between them. The method of recalculation in this cruise is the same as that of

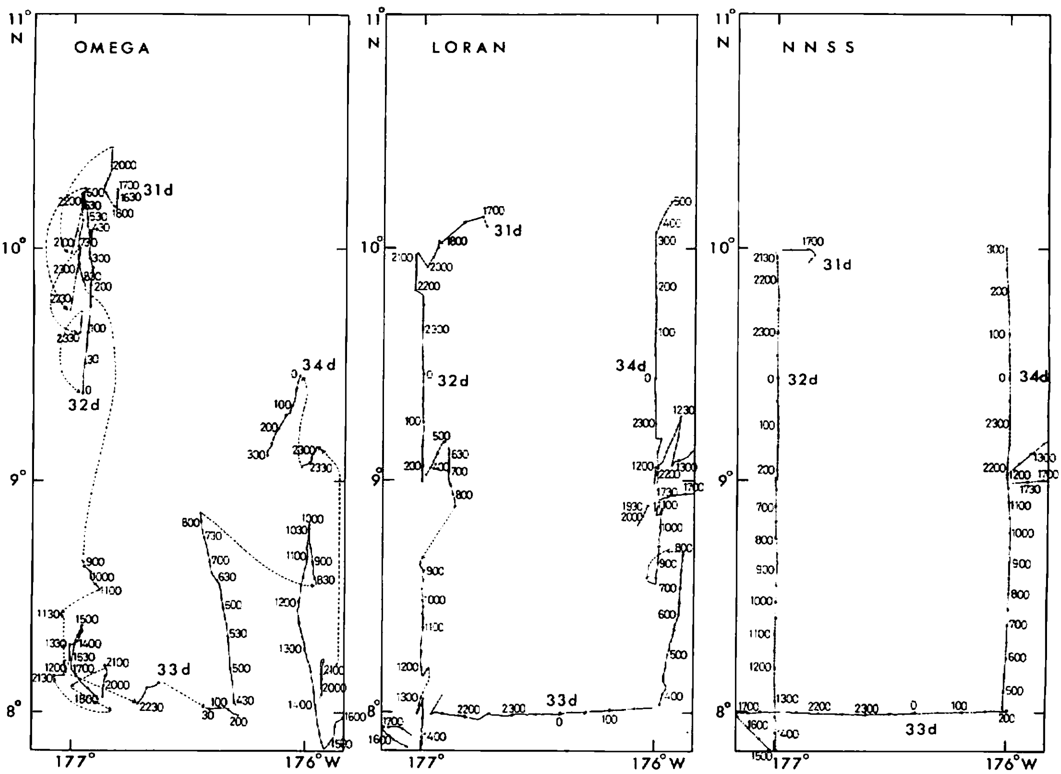

Fig. II–1 Examples of positions by Loran, Omega and NNSS. The numbers of each figure show the GMT (universal time), whose first two figures represent the hour and the last two figures show the minute.

last cruise, GH76–1, which has been discussed by ISHIHARA and ISHIBASHI (1976).

Satellite fixes in the area were obtained most often between 16: 00 and 23: 00 and between 4: 00 and 10: 00 (GMT), and much less in other times. So the accuracy of position is better between the time of much satellite fixes than that of less satellite fixes time. Some statistical properties of satellite fixes in this cruise are shown in Figs. II–2, 3 and 4. Fig. II–2 shows the relation of frequency of satellite fix and update intervals. Fig. II–3 represents update time (GMT) vs. day (GMT). Fig. II–4 is of the relation of corrected distances (ΔR) at update time and update intervals.

Recalculated water velocity is shown in Fig. II–5 in terms of vectors. These water velocity includes the effect of wind and error of initial setting of ship's heading, and so on. Therefore these vectors in the figure do not necessarily show the true water velocities,

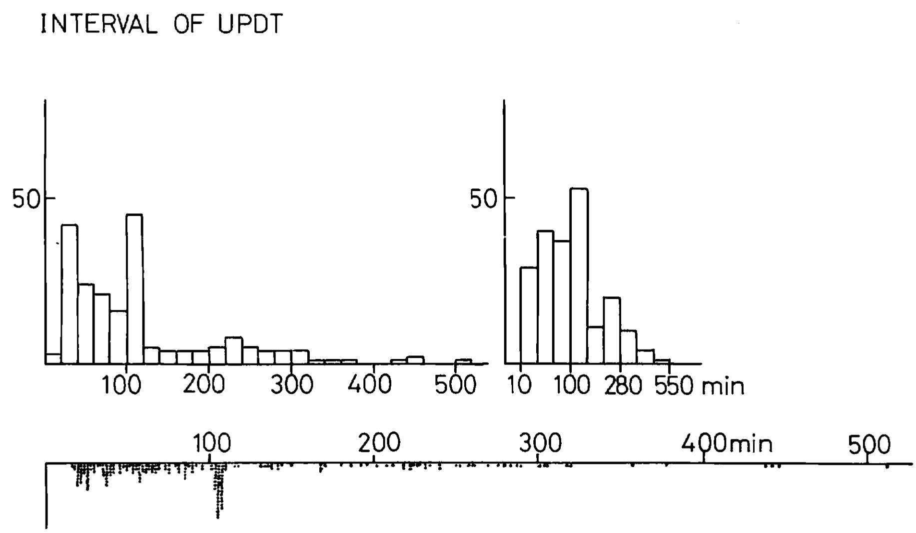

Fig. II–2 Histograms of satellite fix vs. update interval. Horizontal axis shows the update interval in minute and vertical axis shows the number of updates in each range of update time interval. The horizontal scales of each figure are represented in the range of 20 minute, log scale and one minute, respectively.

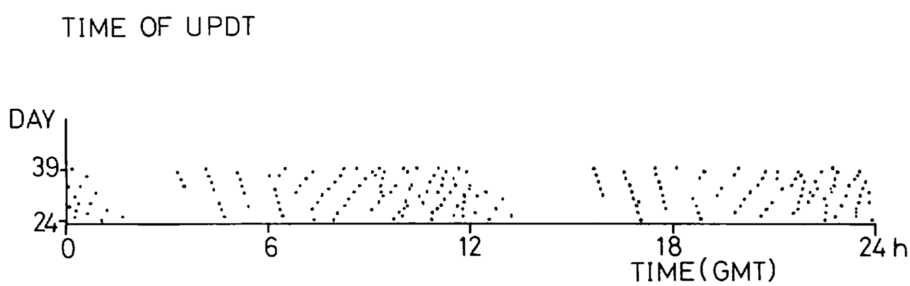

Fig. II–3 Distribution of update time (GMT) in an earlier half period at the survey area.

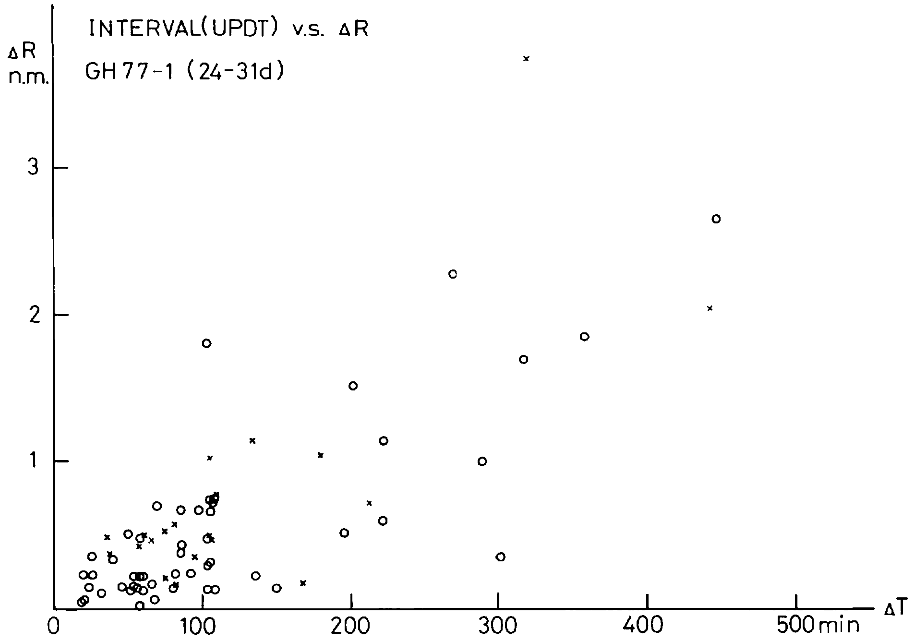

Fig. II–4 Relation between the corrected distances (ΔR) at update time and the update intervals (ΔT). Horizontal axis shows the update interval in minute and vertical axis the distance in nautical mile. Open circles show auto-update and × marks show manual update and there are no remarkable differences in the trends between the two kinds of update data.

but represent such velocities that cannot be detected by ship's velocity sensor. However, these data are useful for navigation by NNSS in the survey area.

As shown in Fig. II–4, a radial difference (ΔR) of a position before and after recalculation generally increases with the time from last update. The relation between the difference and the time is linear,

$$\Delta R = \alpha \times \Delta T \tag{1}$$

where ΔR is the radial distance and ΔT is the time from the last satellite fix. The value of the coefficient α was calculated from the least square fitting of all satellite fixes around the sampling stations;

$$\alpha = 0.00672\ (\text{n.m./min}) = 0.403\ (\text{n.m./hour}) \tag{2}$$

The accuracy of recalculated position is better than that from the original NNSS data, but we cannot estimate exactly the effect of recalculation on the accuracy of positions. Then we use the following equation,

$$\Delta R' = 0.1\ \text{n.m.} + (\alpha/2) \times \Delta T' \tag{3}$$

where $\Delta R'$ is the estimated error and $\Delta T'$ is the time from the closest satellite fix. The first term is the error of satellite fix, and the second term is the dead reckoning error of recalculated position. The second term may be smaller in the case that the water

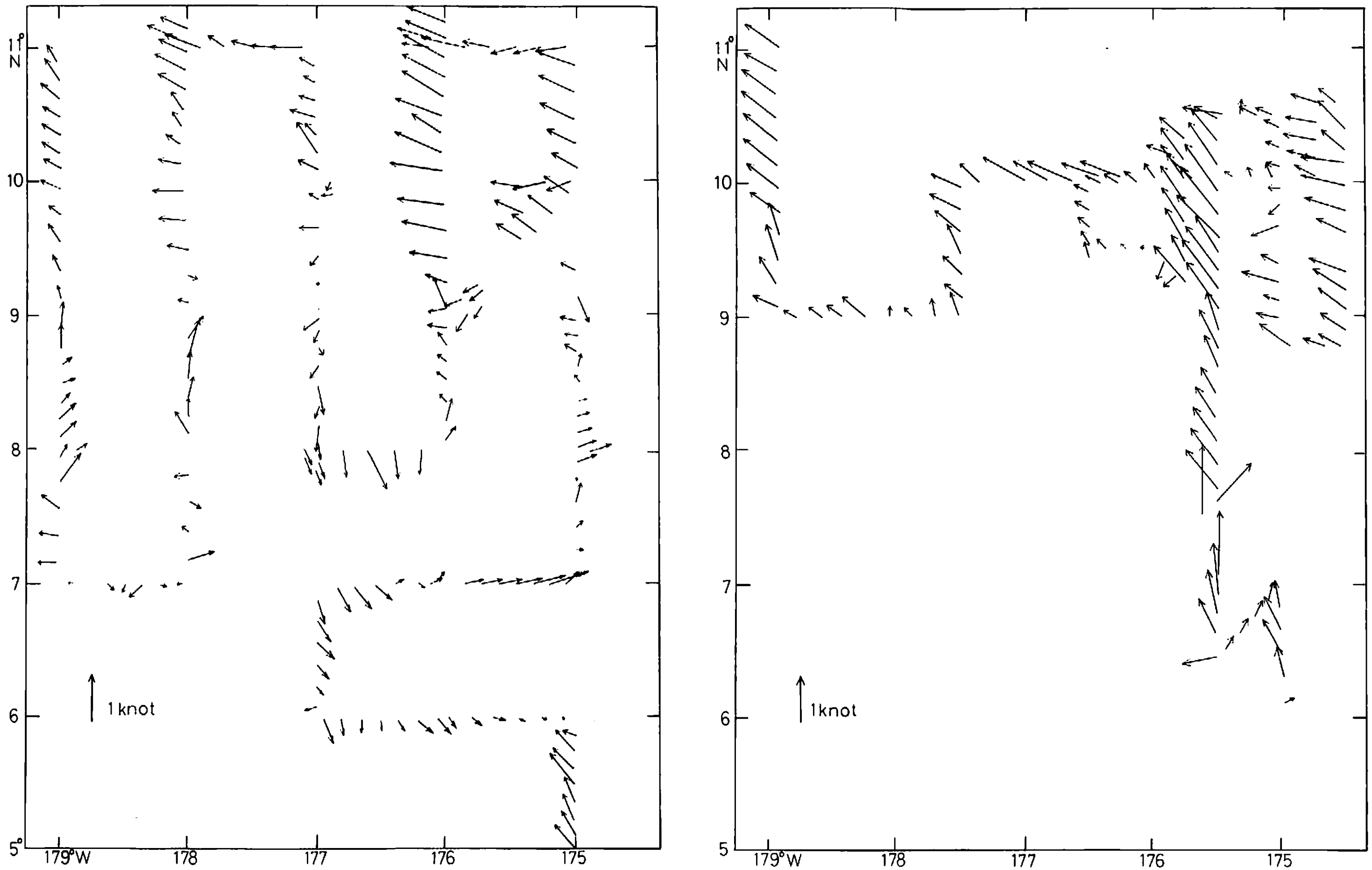

Fig. II-5 Recalculated water velocity shown in the form of vector. They are not true water velocity but may imply the effect of wind, error in velocity sensor, and so on.

Table II–1 Accuracy of positions.

Station no.	Estimated error (n.m.)	Free fall grab no.	Estimated error (n.m.)	Free fall grab no.	Estimated error (n.m.)
701	0.476	FG33–1	0.795	–2	0.809
701A	0.251				
702	0.117	FG34–1	0.248	–2	0.231
703	0.174	FG35–1	0.429	–2	0.436
703A	0.197				
704	0.228	FG36–1	0.224	–2	0.234
705	0.295	FG37–1	0.614	–2	0.604
706	0.15	FG38–1	0.224	–2	0.214
707	0.117	FG39–1	0.412	–2	0.402
708	0.365	FG40–1	0.137	–2	0.147
709	0.92	FG41–1	0.661	–2	0.671
710	0.16	FG42–1	0.187	–2	0.177
711	0.49	FG43–1	0.611	–2	0.621
712	0.15	FG44–1	0.16	–2	0.171
713	0.265	FG45–1	0.402	–2	0.412
714	0.251	FG46–1	0.375	–2	0.386
715	0.221	FG57–1	0.164	–2	0.154
716	0.16	FG56–1	0.248	–2	0.258
717	0.352	FG47–1	0.543	–2	0.554
718	0.187	FG48–1	0.207	–2	0.218
719	0.228	FG49–1	0.187	–2	0.174
719A		FG71–1	0.241	–2	0.298
FG71–3	0.349	–4	0.355	–5	0.288
–6	0.234	–7	0.181	–8	0.127
720	0.261	FG50–1	0.396	–2	0.406
721	0.197	FG51–1	0.459	–2	0.453
722	0.51	FG52–1	0.238	–2	0.248
723	0.255	FG53–1	0.251	–2	0.231
724	0.255	FG54–1	0.211	–2	0.204
725	0.231	FG55–1	0.191	–2	0.177
726	0.312	FG59–1	0.201	–2	0.194
727	0.211	FG58–1	0.144	–2	0.134
728	0.144	FG60–1	0.355	–2	0.332
729	0.181	FG61–1	0.275	–2	0.268
730	0.224	FG62–1	0.268	–2	0.258
731	0.1	FG63–1	0.147	–2	0.137
732	0.171	FG64–1	0.184	–2	0.197
733	0.13	FG65–1	0.248	–2	0.258
733A					
734	0.218	FG66–1	0.187	–2	0.174
735		FG67–1	0.375	–2	0.365
736	0.15	FG68–1	0.107	–2	0.103
737		FG69–1	0.197	–2	0.187
738	0.248	FG70–1	0.285	–2	0.278
739	0.107	FG72–1	0.117	–2	0.13

velocity is constant between last and next updates, because of the decrease of coefficient α.

The position after recalculation and the estimated error according to the relation (3) are shown in Table II–1.

Reference

ISHIHARA, T. and ISHIBASHI, K. (1977) Recalculation of positions by NNSS. *in* A. MIZUNO and T. MORITANI (*eds.*), *Geol. Surv. Japan Cruise Rept.*, no. 8, p. 21–30.